Space Weather Technical Forecast

Issued on Saturday, 23 March 2024 at 00:40 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1/R2 Likely. S1 risk a gradually rising Slight Chance. Chance of G1 peaking Monday 24 March.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 and 18 rose to become Moderate in the UTC day of Friday 22 March, with frequent mid-ranking C-class flares giving way to an M4.2 peaking at 22/2032UTC. This flare emanated from the largest and most complex region on the disc, AR3615. This sunspot region ended the 24 hours as an Fkc/BGD, having undergone rapid development of its trailing spots especially in the period, with extensive growth in its overall penumbral area also seen. This was one of six sunspot regions seeing out the UTC day, a relative decline from the ten that started the period, with western solar horizon exits and fading in situ accounting for the losses. Changes in the remaining spots were relatively small by way of comparison.

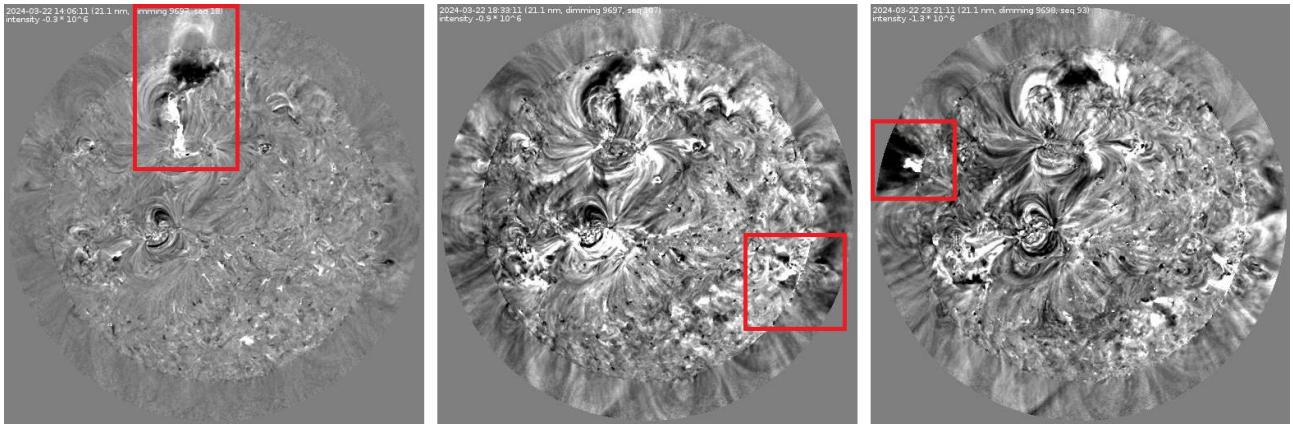

Figure 0: SIDC ROB time integrated dimmings showing unanalysed CME candidates observed in the 24-hour period boxed in red. All are expected to be marginal at worst given their relatively peripheral emission locations, although the rightmost may hint at increased activity to come, perhaps being tied to an arriving sunspot region.

The main activity observed on coronagraphs in the period included a faint Coronal Mass Ejection (CME) seen heading northwest after 22/0700UTC, with the source uncertain but perhaps associated with a filament channel in AIA304 in the northeast. This CME is expected to miss Earth.

Later in the UTC day, a fast, high solar latitude CME was first visible on Lasco C2 around 22/1500UTC. This appeared to initially trigger from immediately east of AR3614, following a magnetic neutral line for a time before leaving the disc largely aimed northward. Modelling for this event is pending as of the time of issue of this guidance document. There were then events from the southwest quadrant (a possible filament eruption seen at 22/1700UTC), and also an AIA211 dimming near a possible arriving region on the northeast limb (at 22/2230UTC). Both of these events are awaiting imagery for modelling.

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Finally, at the time of writing, there was no obvious dimming nor ejecta visible in extreme UV emanating from the M4.2 event - this remains a source of monitoring given its approach to centre disc. No Earth-bound CMEs were therefore identified in the period.

Solar Wind / Geomagnetic Activity: The solar wind at L1 measured by ACE and DSCOVR started under the influence of the tail of the magnetic cloud stemming from the 17 March CME arrival around 21/1500UTC. This perhaps gave way to a slow regime around 22/0500UTC, with a minor step change visible in many solar wind measures at this time.

The solar wind speed was within Background levels throughout, falling slightly from 350-375 to nearer 325-350km/s over the 24 hours. The solar wind density fell over the same interval from early highs of around 15ppcc to single figures. The IMF peaked near 10nT with a relatively stable magnitude, with the north-south component showing an overall positive bias to peak at +9nT, with a brief foray as low as -6nT as a parting shot from the CME influence. The phi angle showed a slight bias towards a negative sector (towards the Sun), although this was quite a weak tendency.

The net result of the above solar wind measures was for provisionally Unsettled geomagnetic activity, gradually falling to Quiet, with a peak Kp of '3+' in the 00-03UTC interval.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux has remained at Background levels.

High energy electron flux (greater than 2MeV) observed at GOES16 was at Normal Background levels. The observed 24-hour fluence was below the Active threshold, with a value at 23/0001UTC of 9.19e5 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is Likely, with isolated M-class flares probable from AR3615 and a Slight Chance of X-class. The most significant front side region (AR3615) remains present throughout the four days, and there are now signs that there may be an oncoming active region in the northeast. The flare risk is now held constant throughout the four days.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. The next notable enhancement will be from the arrival of the fast winds of CH12/-, most likely on Day Two (Monday 24 March) with Slightly Elevated to Elevated solar winds forecast (450-500km/s). Mainly Quiet geomagnetic activity is expected to bookend this arrival, separated by a peak Chance of isolated G1 Minor Storm intervals on Monday 24 March.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 is expected to persist at Background, albeit with a rising Slight Chance of enhancement from any notable flaring from AR3615.

High energy electron flux (greater than 2MeV) is expected to persist at Normal Background levels at first, but may respond upwards towards the middle of the coming UTC working week should the fast wind from CH12 lie nearer the higher end of estimates for potency. The associated 24-hour fluence is expected to persist below the Active threshold, but with an eventual rising trend probable.

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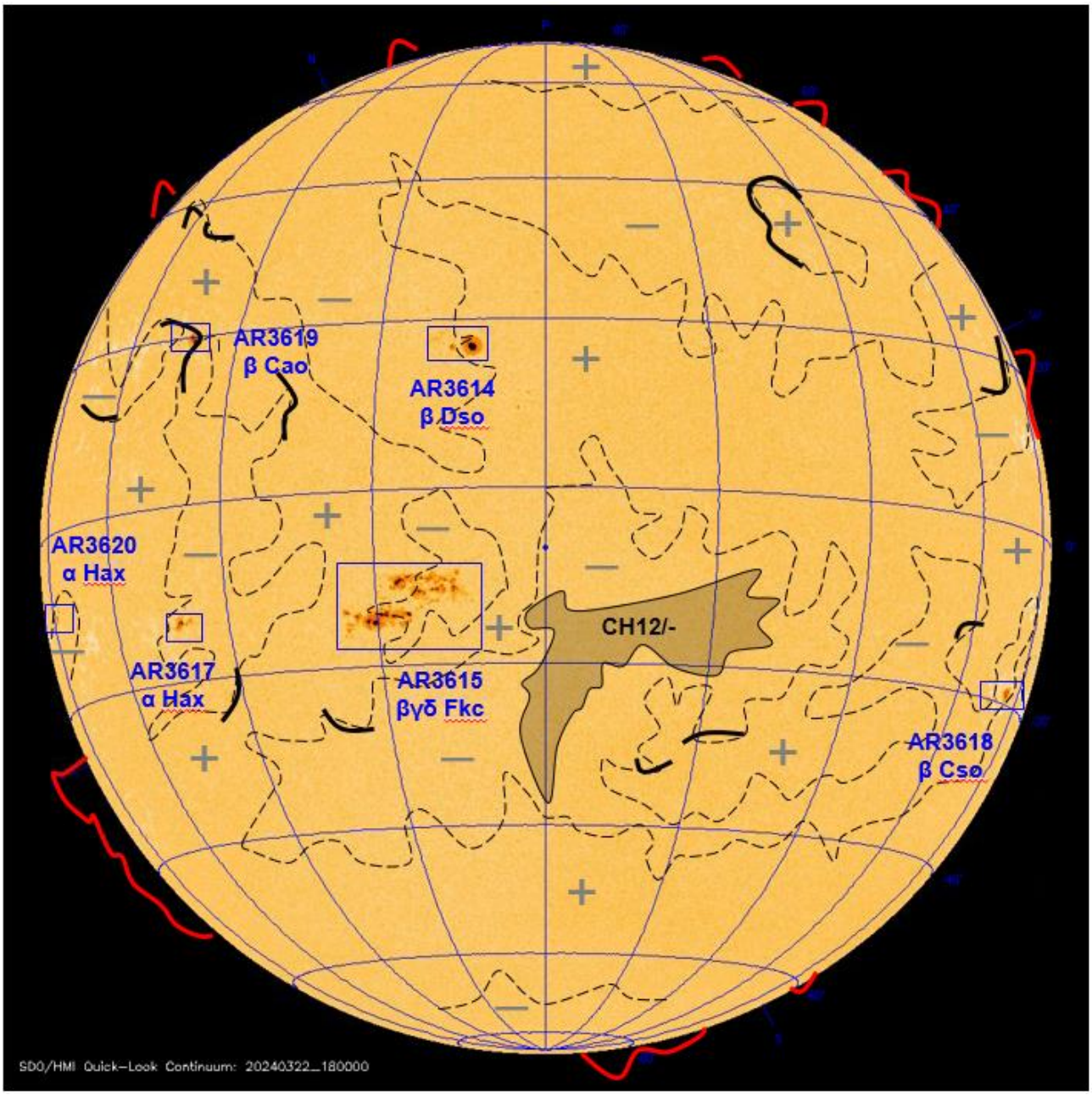
Figure 1. Solar Analysis Valid 22/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs in the current forecast.

Forecast geomagnetic activity is therefore heavily vested in the onset and eventual magnitude of the fast wind from CH12/-. This coronal hole is expected reach its apparent geoeffective longitude on Day 2 (Monday 24 March) with observed solar winds expected to rise in response to become Slightly Elevated (around 450km/s), and perhaps briefly Elevated (500km/s). CH12/- is a persistent feature, with solar winds of around 450km/s observed on the previous rotation, along with an isolated G1 Minor Storm interval. Given the proximity of the equinox, similar coordinates and geometry of CH12/-, similar conditions are also likely on this occasion. Slightly Elevated solar winds should then persist into the new working week before beginning to ease by the end of the four days.

MOSWOC Enlil currently has this fast wind passing south of Earth, leading to some uncertainty, however given its apparent location visually in EUV (e.g. in AIA211) a stronger connection at a analagous time to last pass is the most likely forecast.

Geomagnetic activity should start and end the four days as Quiet, with an intervening peak Chance of G1 on Sunday 24 March, bleeding into the following 24-hour UTC day given its expected arrival later in the UTC day of Sunday.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	1	50	20	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil, although note that there are some unassessed candidates.

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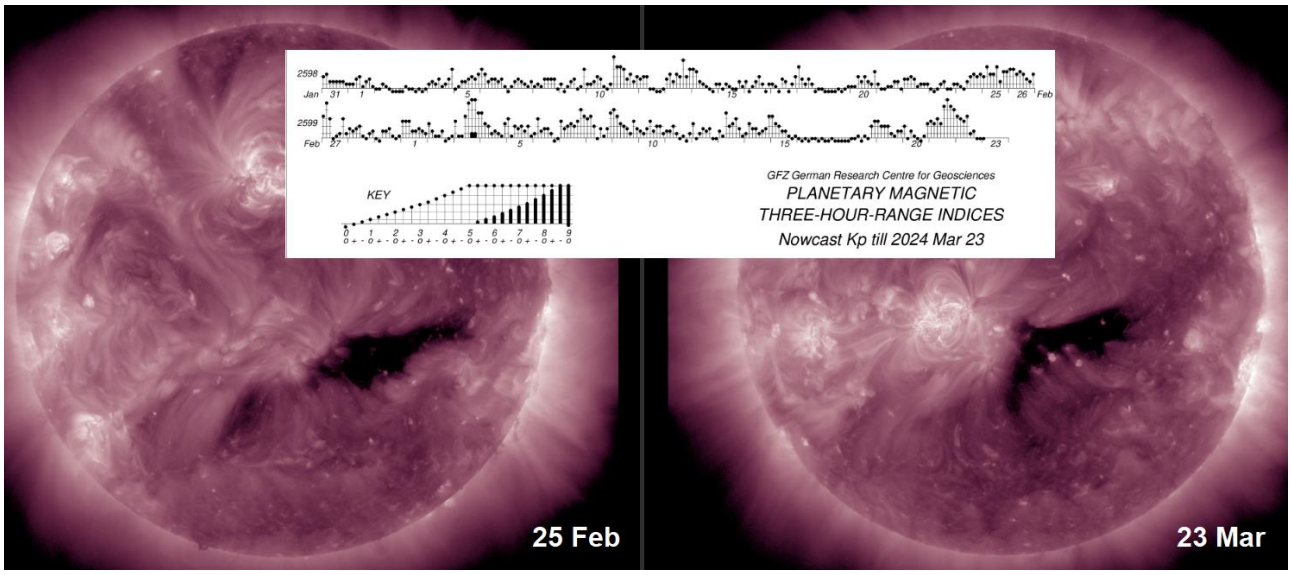
Figure 2: AIA211 imagery from past and present rotations, showing the relative appearance of CH12/- and its predecessor. Also shown is geomagnetic activity in the form of a Bartels music plot, with an isolated G1 interval recorded on last pass.



Radio Blackouts - X-Ray Flares:

The current Earth-facing disc is dominated in terms of activity by AR3615, and the most recent Penticton 10.7cm flux measurement is at a high for the rotation at 198sfu. AR3615 now comprises a large number of small umbrae, with mixing of its constituent magnetic polarities resulting in a Mt Wilson Beta-Gamma-Delta configuration. Ongoing darkening of the umbrae, along with emergence of further trailing spots and joining of the penumbral regions suggests a strengthening trend, in part demonstrated by the late M4.2.

The above sunspot remains present throughout the four days of the forecast period, and while no significant sunspot regions leave in the same interval, there are now signs in EUV (AIA094 especially) that there may be a new oncoming region in the northeast to help bolster the risk of activity. All considered, M-class flares are Likely on all days, with a level tendency, with a corresponding Slight Chance of X-class.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	15	15	15	15

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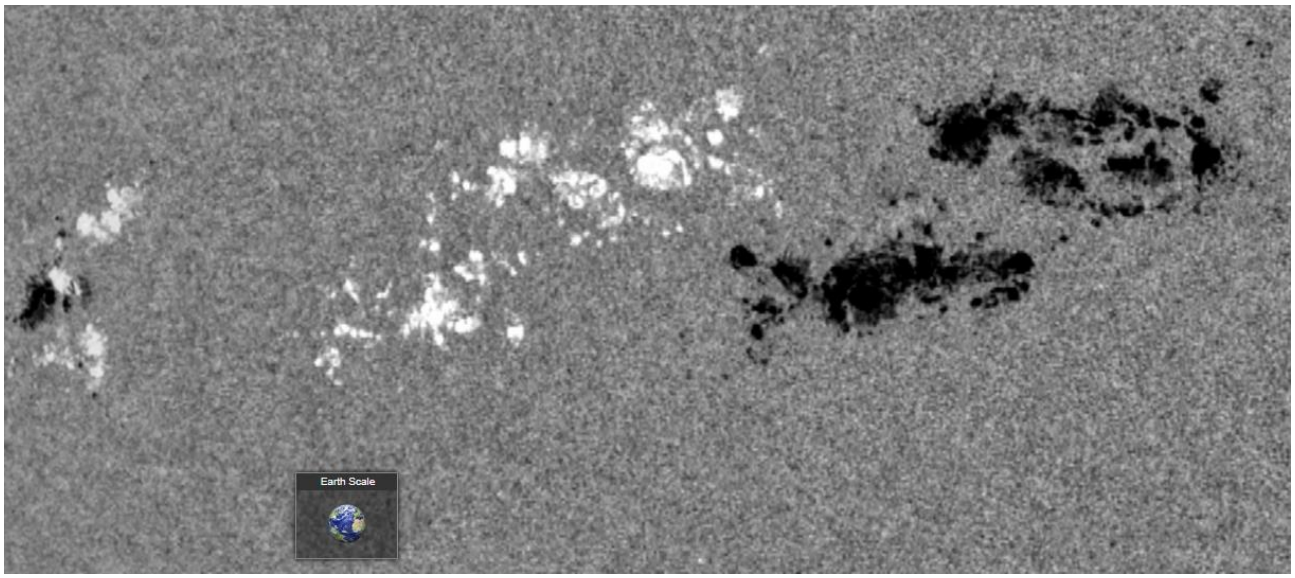
Figure 3: Helioviewer.org 48-hour evolution of AR3516, showing its previous footprints at 21/2300UTC and 20/2300UTC in HMIIF in white, and current 22/2300UTC in black (rightmost group). Note the significant increase in span and overall area during that timeframe. Earth shown for scale.



Solar Radiation Storms - (High Energy Protons):

High energy proton flux, as observed by GOES18 is currently at Background levels. While a continuation of this tendency is most likely, the dominant AR3615 should make continued progress westward through this four-day period to gradually increase the risk of S1 day-on-day, with contributions from other regions paling in comparison at the time of writing.

It remains to be seen as to whether Ar3615 has a tendency toward proton-rich flares, as any emanating from its current location near centre-disc are not in a prime location to connect.

Radiation Storms Probability (Exceedance)	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC) (%)**	**Day 2 (00-24 UTC) (%)**	**Day 3 (00-24 UTC) (%)**	**Day 4 (00-24 UTC) (%)**
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

GOES16 high energy electron flux is expected to remain at Normal Background levels before the next potential enhancement occurs from the fast wind of coronal hole 12. Once any associated geomagnetic activity eases, the electron flux at GEO is likely to rise to Moderate, with a Slight Chance of reaching High into the new UTC working week. This is low confidence however, as the source coronal hole (CH12/-) is a persistent feature and no electron flux enhancement was observed on the previous rotation.

Despite the above, the most likely state of affairs is for the associated 24-hour fluence to remain below the Active threshold, with MOSWOC REFM providing good guidance until the onset of this fast wind. Fluence is likely to rise a little into the new UTC week, with a Slight Chance of reaching Active fluence by the end of the period.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	1	10	20
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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